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Cooperative Studies on the Effects of Height of Ridge, Nitrogen Supply, and Time of Harvest on Yield and Flesh Color of the Porto Rico Sweetpotato

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United States Department of Agriculture, Agricultural Research Administration, Bureau of Plant Industry, Soils, and Agricultural Engineering, in cooperation with the Agricultural Experiment Stations of Georgia, South Carolina, and Texas

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[1] George P. Hoffmann, deceased, formerly horticulturist, conducted the tests at Meridian, Miss., in 1940.

[2] The authors gratefully acknowledge the assistance of Victor R. Boswell, principal horticulturist, and assistant head of division, and E. C. Tatman, principal agricultural aid, Division of Fruit and Vegetable Crops and Diseases, in the planning of these studies and preparation of the manuscript and in the statistical analysis of the data, respectively.

INTRODUCTION

Sweetpotatoes are produced for three more or less distinct purposes: (1) Human food; (2) animal feed either as a fresh product or in dried, or dehydrated, form; and (3) starch extraction, alcohol production, and other industrial utilization. In the United States production for human food is by far the most important and extensive at present. One of the most widely grown varieties for this use is the Porto Rico, including its various strains. It is the most important variety grown in Georgia, Louisiana, Mississippi, North and South Carolina, and Texas.

Numerous problems in the production of Porto Rico sweetpotatoes have attracted the attention of growers, research workers, and extension specialists. In general, these involve the improvement of the variety and its various strains by breeding and selection and the evaluation and improvement of cultural practices. Some of these problems are local and are best solved by the local experiment station; others are regional and are most effectively solved by coordinated action of several experiment stations within the production region.

In 1939 a conference was held by representatives of the Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture, and of the Agricultural Experiment Stations of Georgia, Louisiana, Mississippi, South Carolina, Texas, and Virginia to determine the pertinent production problems that could be investigated on a regional basis and to outline plans of procedure that could be uniformly applied at all locations. Among such problems were those involving the optimum time for harvesting the fleshy roots for storage and late market, the influence of a comparatively high or low supply of available nitrogen, and the effects of height of planting ridge on the grade, yield, and color of the roots. To obtain experimental evidence of the effects of these factors and their interactions, coordinated experiments were conducted at four locations in 1940, 1941, and 1942. The more pertinent results are presented in this circular.

MATERIALS AND METHODS

CLIMATE AND SOILS AT THE COOPERATING STATIONS

These studies were conducted at the United States Horticultural Field Station, 6 miles northeast of Meridian, Miss., the Georgia Coastal Plain Experiment Station, 1 mile north of Tifton, Ga., the Edisto Experiment Station, 3 miles west of Blackville, S. C., and the Texas Sweet Potato Investigations Laboratory, 2 miles south of Gilmer, Tex. These stations are located in widely scattered areas, but are situated within or near commercial sweetpotato-producing districts and experience has shown that the normal temperatures and rainfall at these locations are favorable for sweetpotato production. Climatic conditions at the several locations during these tests are given in tables 1 and 2.

TABLE 1.—*Killing-frost dates, lengths of frost-free periods, and seasonal temperature and rainfall levels at 4 locations in 3 years*

Location and year	Date of killing frost		Frost-free period	Temperatures [1] [2]			Rainfall [1] [2]		
	Last in spring	First in fall		Early [3]	Midseason [3]	Late [3]	Early [3]	Midseason [3]	Late [3]
Blackville:			*Days*						
1940	Apr. 13	Nov. 9	209	− − to + +	+ to −	− to +	+ to −	− − to + +	− −
1941	Mar. 19	Nov. 10	235	+ + to −	0 to +	+ to + + +	− − − to + + +	+ + + to −	0 to + + +
1942	Mar. 4	Nov. 12	252	−	+ to − −	0	0 to + + +	− −	− −
Tifton:									
1940	Apr. 13	Nov. 15	215	− − to −	− − to −	− −	− − − to + +	+ + + to 0	− −
1941	Mar. 18	Nov. 26	252	+	− to + +	0 to + + +	− − − to + +	− to − −	− to − − −
1942	Mar. 4	Nov. 25	265	−	+ to −	−	+ +	− −	+ + to − − −
Meridian:									
1940	Apr. 13	Nov. 14	214	−	− to 0	− to +	− −	+ + + to − −	− − − to + +
1941	Mar. 30	Nov. 9	223	+ + to +	− to + +	+ + +	− − −	+ + + to − − −	0
1942	Feb. 28	Oct. 27	240	0 to +	+ to 0	− to +	− −	− − to +	+ + to 0
Gilmer:									
1940	Apr. 13	Nov. 12	212	−	− −	− − to +	+	− − to + +	− − − to + +
1941	Mar. 11	Nov. 17	250	+ + to − −	0 to −	+ + +	0 to + + +	− − to + +	+
1942	Apr. 1	Nov. 24	236	0	−	− to 0	0	− − − to + + +	+ + to −

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[1] Average levels of temperature and rainfall, expressed with reference to the normal for each location, listed in the order of occurrence within each seasonal period.

[2] 0, Normal temperature or rainfall; −, slightly low temperature or slightly light rainfall; − −, low temperature or light rainfall; − − −, very low temperature or very light rainfall; +, slightly high temperature or slightly heavy rainfall; + +, high temperature or heavy rainfall; + + +, very high temperature or very heavy rainfall.

[3] Early, May and June; midseason, July and August; late, September and October.

The types of soil used varied with the cooperating stations as follows: At the United States Horticultural Field Station, a Ruston fine sandy loam in 1940, a Ruston loamy sand in 1941, and a Red Bay fine sandy loam in 1942; at the Georgia Coastal Plain Experiment Station, a Tifton sandy loam in all 3 years; at the Edisto Experiment Station, a Marlboro sandy loam in 1940, a Norfolk sandy loam in 1941, and a Ruston sandy loam in 1942; at the Texas Sweet Potato Investigations Laboratory, a Bowie fine sand in all 3 years. With the exception of the Bowie fine sand, which was shallow, gravelly, and deficient in organic matter, all of these soils were well adapted to sweetpotato production.

Table 2.—*Normal and observed mean temperatures and rainfall for May through October at 4 locations in 3 years*

Location and month	Mean temperature				Rainfall			
	Normal	Observed for year shown			Normal	Observed for year shown		
		1940	1941	1942		1940	1941	1942
Blackville:	*° F.*	*° F.*	*° F.*	*° F.*	*Inches*	*Inches*	*Inches*	*Inches*
May	73.0	71.2	74.7	72.6	3.3	4.2	0.6	3.7
June	79.3	80.8	78.4	78.8	5.5	4.6	8.6	8.8
July	81.3	81.8	81.2	81.7	5.2	3.6	7.7	4.4
August	80.5	80.0	81.2	78.2	5.1	7.7	4.0	4.0
September	76.1	74.4	77.3	76.1	4.3	1.1	4.5	3.1
October	65.4	66.5	71.6	66.2	2.7	.9	6.3	1.1
Tifton:								
May	73.4	71.8	73.9	73.1	3.4	1.4	1.2	5.1
June	79.2	78.8	79.4	78.2	4.8	5.5	8.0	6.6
July	80.8	79.6	80.2	81.6	6.5	11.0	6.0	3.2
August	80.5	80.4	82.0	79.8	5.5	5.3	2.4	4.8
September	77.7	74.1	78.0	76.6	3.7	1.6	3.2	4.8
October	68.0	66.6	73.8	67.7	2.1	.8	1.0	.8
Meridian:								
May	71.3	69.6	73.8	71.0	4.3	1.1	.4	2.7
June	78.0	77.4	79.2	79.4	4.6	4.1	2.7	3.7
July	80.4	79.4	81.4	81.8	4.9	16.0	13.7	2.1
August	79.5	80.0	81.6	79.4	4.5	1.4	1.1	5.4
September	74.5	73.4	78.9	73.0	3.0	.9	2.8	5.7
October	64.3	65.9	72.2	66.0	2.4	4.1	2.6	2.7
Gilmer:								
May	72.3	70.6	74.3	72.2	4.0	4.6	3.9	4.0
June	79.9	78.2	77.6	80.1	2.9	5.2	14.9	3.8
July	83.9	80.9	82.1	81.6	3.3	2.9	2.0	.6
August	83.3	80.6	82.0	81.9	2.3	4.0	4.5	8.0
September	76.5	74.4	77.8	73.9	2.5	.7	2.6	5.3
October	65.6	68.6	71.9	66.4	2.8	5.4	4.5	2.0

SOURCE OF SEED STOCK

Plants of the Unit I strain of the Porto Rico variety (herein designated "Porto Rico") were used throughout these studies. Each worker obtained seed stock from the originator, J. C. Miller, of the Louisiana Agricultural Experiment Station, for establishing the plots in 1940 and used seed stock from this strain which had been produced at the respective stations for establishing the plots in 1941 and 1942. In all cases roots of U. S. No. 1 and U. S. No. 2 grades, free from diseases and offtype mutations, were used.

General Cultural Practices

Methods of plant production, soil preparation, fertilization, cultivation, and harvesting varied according to prevailing practices at each location.

At Blackville, the roots were soaked in a 1–1,000 solution of corrosive sublimate for 8 minutes and immediately bedded in a 6-inch layer of Norfolk sandy soil in a flue-heated, cloth-covered hotbed. At Tifton, the roots were treated with a 1–1,000 solution of corrosive sublimate for 8 minutes and were bedded in a well-drained sandy loam in the field in 1940 and in a cornstalk-heated, cloth-covered hotbed in 1941 and 1942. At Meridian, the roots were treated with a 1–1,000 solution of corrosive sublimate for 8 minutes and immediately bedded in a 5- to 6-inch layer of sand upon which was placed a ½-inch layer of old hardwood sawdust in a sash-covered, electrically heated hotbed. At Gilmer, the roots were treated with Semesan Bel and bedded in a 6-inch layer of old hardwood sawdust in a sash-covered, cornstalk-heated hotbed. In all locations, with the exception of Tifton in 1940, relatively warm, moist media were maintained to insure fairly rapid and adequate plant production.

In most cases the land was plowed 6 to 9 inches deep at least1 month before the plants were set and was disked and redisked when necessary about 1 week before planting to pulverize the clods and to make a fine plant bed. In 1940 at Meridian, instead of the usual plowing, the initial operation consisted of disking the land 4 to 6 inches deep. Planting ridges were thrown up 2 to 3 inches above the desired height by means of horse- or tractor-drawn plows.

Fertilizer analyses and rates of application used at the cooperating stations are indicated in table 3. Two types of fertilizer mixtures, a relatively high nitrogen mixture and a low-nitrogen one, were used at all locations. The high-nitrogen mixtures varied from 5 percent of available nitrogen at Blackville to 10 percent at Meridian, and the low-nitrogen mixture contained only 1 percent of available nitrogen at Blackville and 2 percent at the other stations. The percentages of phosphorus and potassium in the mixtures were practically the same as in mixtures generally used and recommended for sweetpotato production in these southern districts. These mixtures were moderately high in phosphorus and high in potassium.

At Tifton, Meridian, and Gilmer the conventional method of applying fertilizers was used in all years. Field operations consisted of marking out rows 4 feet apart, making furrows, applying the fertilizer in the bottom of the furrow, mixing the fertilizer with the soil, and throwing up the ridges, or rows. To place the fertilizer at practically the same distance below the transplants with the different ridge heights, furrows were made of varying depths depending on the height of the ridge: 5 to 6 inches for the low ridge, 3 to 4 inches for the medium, and 1 to 2 inches for the high. At Blackville the fertilizer was applied according to the conventional method in 1940, whereas half of the mixture was applied according to the conventional method and the remainder as a side dressing about 3 weeks after the plants were set in 1941 and 1942.

TABLE 3.—*Analyses and rates of application of fertilizers at 4 locations in 3 years*

Location and period or year	Fertilizer analysis		Rate per acre	Nitrogen applied per acre	
	High nitrogen	Low nitrogen		High	Low
			Pounds	*Pounds*	*Pounds*
Blackville (1940–42)	5–8–8	1–8–8	1,000	50	10
Tifton (1940–42)	8–8–8	2–8–8	800	64	16
Meridian:					
1940	10–8–8	2–8–8	1,000	100	20
1941	8–8–10	2–8–10	1,000	80	20
1942	8–8–8	2–8–8	1,000	80	20
Gilmer (1940–42)	8–8–10	2–8–10	600	48	12

In all tests all the plants for any one block were pulled and set the same day. All were set by hand, 12 inches apart, and "watered in." In general, good stands resulted. Dates of planting at the various locations are shown in the second column of table 4.

TABLE 4.—*Planting and harvesting dates at 4 locations in 3 years*

Location and year	Date of planting	Date of harvest			
		First	Second	Third	Fourth
Blackville:					
1940	May 10	Aug. 31	Sept. 20	Oct. 8	Oct. 30
1941	May 1	Sept. 2	Sept. 22	Oct. 10	Oct. 31
1942	Apr. 30	Sept. 1	Sept. 22	Oct. 12	Oct. 31
Tifton:					
1940	June 4	Sept. 1	Sept. 26	Oct. 20	Nov. 10
1941	Apr. 24	Sept. 2	Sept. 29	Oct. 22	Nov. 10
1942	May 13	Sept. 1	Sept. 24	Oct. 20	Nov. 11
Meridian:					
1940	May 28	Sept. 2	Sept. 26	Oct. 21	Nov. 13
1941	May 19 and 29 [1]	Sept. 2	Sept. 25	Oct. 20	Nov. 12
1942	May 22 and June 4.[1]	Sept. 1	Sept. 24	Oct. 19	Nov. 10
Gilmer:					
1940	May 1	Sept. 19	Sept. 27	Oct. 18	Nov. 15
1941	May 29	Sept. 17	Oct. 2	Oct. 16	Nov. 12
1942	May 18	Sept. 3	Sept. 21	Oct. 8	Nov. 9

[1] 3 of the 4 blocks planted at the earlier date shown.

At least two or three cultivations and two or three hoeings were given the plots each season to control grass and other weeds. Care was taken during these operations to maintain the desired ridge heights.

At each location roots were harvested each year on four successive dates. The third harvest date, which was at the average first-killing-frost date or the time of onset of fall rains or low temperatures for each location, was arbitrarily selected as the optimum digging date. The two preceding harvests and the one succeeding harvest were timed with relation to the third harvest dates and with planned intervals of about 3 weeks between harvests. Because of uncontrollable weather and other factors, sometimes the actual harvest dates deviated from those intended; and intervals between harvests were shortened or lengthened accordingly. Harvest dates for the several locations and years are given in table 4. Although light frosts sometimes occurred earlier, during these tests the first killing frosts occurred considerably later than the third harvests and were always nearer to the fourth than the third harvest dates. In this circular the several harvests are designated by their order of occurrence rather than by dates.

Harvesttime operations consisted in cutting the vines, in plowing out the rows, in collecting the roots and grading them into Jumbo, U. S. No. 1, U. S. No. 2, and cull grades,[3] and in counting and weighing the roots of each grade. The vines were cut either with hoes just prior to plowing out or by means of knives attached to the plow beam. Horse-drawn plows or diggers were used except in one or two tests in which the diggers were tractor-drawn. The roots were "scratched out" from the furrow slice by hand and left on the surface of the soil for 2 to 3 hours to facilitate removal of excess soil from their surfaces before they were graded by hand and weighed.

After grading and weighing, five or more roots of modal size and shape from each field plot were set aside for comparative readings on flesh colors. The remaining storable roots from each field plot were divided equally into four crates for use in subsequent storage studies. At the conclusion of the storage periods additional samples representative of the various field treatments were selected for flesh-color evaluations.

Although the primary yields for each grade were determined without regard to cutting or other mechanical harvesting injuries, separate determinations were made of roots cut in harvesting in order to evaluate the relative extent of such losses likely to occur with different heights of ridge, harvest periods, and nitrogen levels.

FIELD-PLOT ARRANGEMENT

The treatments were arranged in a split-plot, Latin-square field design with each test containing 4 blocks, or replications. In 1940 each of the 4 time-of-harvest plots was split longitudinally with the high-nitrogen application placed at random on one half and the low-nitrogen on the other. The 3 ridge treatments were arranged at random within each nitrogen subplot. Since there were 32 nitrogen subplots, each ridge height occurred 32 times. Individual plots consisted of single 50-foot rows. All rows were spaced 4 feet apart. With this arrangement considerable difficulty was encountered in constructing and maintaining the desired height of ridges, and at harvest many individual plots were found to have produced insufficient roots for subsequent storage investigations.

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[3] Grading of roots for size and shape was accomplished essentially according to standards set up by the Bureau of Agricultural Economics, U. S. Department of Agriculture, Sept. 8, 1925. (U. S. Grades for Sweet Potatoes (1925).) 3 pp. 1925. [Processed.])

In order to provide a more satisfactory field arrangement and more roots for storage, in 1941 and 1942 the plots consisted of two 50-foot rows each and the positions of the nitrogen and ridge plots within the time-of-harvest plots were reversed. Thus, each subblock, or time-of-harvest plot, was divided lengthwise into three equal parts given over to the three ridge treatments placed at random. The nitrogen treatments were arranged at random within each ridge treatment.

Medium-ridge guard rows were maintained at the boundaries of each time-of-harvest plot (each subblock), between the nitrogen plots of the subblocks in 1940, and between ridge heights in the subblocks in 1941 and 1942.

To provide adequate space for turning of the equipment, particularly during harvests, 10-foot alleys were maintained between tiers of plots.

Root-Color Determinations

At all locations except Blackville color readings at harvesttime were made as soon after digging as practicable, usually within 1 or 2 days; those after storage were made within a day or two of the time the roots were withdrawn from the several storage rooms. At Blackville roots from the several harvests were held until completion of the fourth harvest, when all before-storage color readings were made at one time.

At Meridian, Tifton, and Gilmer proximal-end flesh colors were recorded according to Maerz and Paul's designations (*9*).[4] Since only slight variations in yellow and gray color values were found in these roots, the color data and discussions presented in this circular concern only the numerical designations for intensity of red colors in the flesh, which were averaged for all roots in each treatment sample. At Blackville the flesh colors were recorded on an arbitrary scale of 1 to 7, in which 1 represented a creamy-white color; 2, one-half creamy white and one-half pink;[5] 3, pink; 4, one-fourth salmon-pink[5] and three-fourths pink; 5, one-half salmon-pink and one-half pink; 6, three-fourths salmon-pink and one-fourth pink; and 7, all salmon-pink.

Statistical Analysis of the Data

Fisher's method (*5*) of analysis of variance was used in evaluating the data. It was apparent that there were wide differences in yields both at single locations in different years and among locations in one or more years; consequently the data were tested for homogeneity of error before the data for years or for places were combined for analysis. Only data showing homogeneous error variances were subjected to combined analyses.

Inasmuch as the field-plot arrangement was the same only in 1941 and 1942, only data for these two seasons have been combined in statistical evaluations of results for more than a single year.

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[4] Italic numbers in parentheses refer to Literature Cited, p. 40.

[5] In these readings pink and salmon-pink approximate the colors peach (*9, pl. 9*) and trianon (*9, pl. 9*) to salmon (*9, pl. 10*).

EFFECT OF VARIOUS FACTORS ON YIELDS

Location and Season

Mean yields[6] obtained in each of the 3 years and for all years and for 1941 and 1942 taken together for each of the four locations are presented in table 5.

Table 5.—*Mean yields per acre of Porto Rico sweetpotatoes at 4 locations in 3 years*

Location and year	Roots of indicated grade				
	Jumbo	No. 1	No. 2	Cull	Total
Blackville:	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1940	28.9	91.6	102.7	39.5	262.7
1941	34.5	163.3	41.6	20.0	259.4
1942	16.9	152.2	66.5	26.4	262.0
Mean (3 years)	26.8	135.7	70.2	28.7	261.4
Mean (1941 and 1942)	25.7	157.8	54.1	23.2	260.7
L. S. D.[1] between 1941 and 1942	8.5	10.2	7.5	(2)	(2)
Tifton:					
1940	.8	83.0	31.9	46.3	162.0
1941	5.2	206.4	27.7	13.6	252.9
1942	.5	90.3	37.8	54.0	182.6
Mean (3 years)	2.2	126.6	32.5	38.0	199.3
Mean (1941 and 1942)	2.9	148.4	32.8	33.8	217.8
L. S. D.[1] between 1941 and 1942	--------	23.1	(3)	4.3	(3)
Meridian:					
1940	5.9	58.0	42.4	18.4	124.7
1941	5.4	110.6	51.5	42.6	210.1
1942	5.2	128.2	47.8	40.6	221.8
Mean (3 years)	5.5	99.0	47.2	33.9	185.5
Mean (1941 and 1942)	5.3	119.4	49.7	41.6	216.0
L. S. D.[1] between 1941 and 1942	(2)	(2)	(2)	--------	(2)
Gilmer:					
1940	12.5	77.3	116.7	59.5	266.0
1941	8.6	71.3	134.7	34.1	248.7
1942	4.3	111.5	67.2	37.7	220.7
Mean (3 years)	8.5	86.7	106.2	43.8	245.1
Mean (1941 and 1942)	6.5	91.4	101.0	35.9	234.7
L. S. D.[1] between 1941 and 1942	--------	17.5	(3)	(2)	(2)

[1] Least significant difference at 5-percent level calculated from the sum of block and block × year interactions considered as error.

[2] Differences not significant at 5-percent level.

[3] Error variances for 1941 and 1942 were heterogeneous and data were therefore not combined for statistical analyses.

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[6] All yield data were calculated and are presented in this paper on the basis of 60 pounds to the bushel.

In general the production of Jumbo roots was relatively low at all locations although noticeably higher and more consistent at Blackville than at the other three locations. This low incidence of oversize roots very likely resulted from the 12-inch spacing of plants and the existence of good stands. Beattie, Boswell, and Hall (*2*) showed that close spacing reduces the yields of Jumbo roots without materially altering those of roots of the No. 1 grade.

Yields of roots of No. 1 and No. 2 grades varied considerably among the 3 years at each location. Total yields were usually somewhat less variable among years at the several locations than were those of the separate grades.

In the majority of cases differences between average yields in 1941 and 1942 for the separate grades at single locations lacked significance when referred to the variances for blocks within years as "error." However in the No. 1 grade, yield differences between these 2 years were significant at Blackville, Tifton, and Gilmer, but not at Meridian. In no case was the total yield significantly different in the 2 years when evaluated on this basis.

Marked variations in yields among years at any given location and even among locations in a given year are to be expected, since numerous factors influence the size and grades of the crop. In these experiments some important factors concerned were type and fertility of soil, kind and amount of fertilizer used, time of planting, weather conditions during the period of plant recovery after planting, and amount and distribution of rainfall during the growing season.

Although differences in yields among years at single locations are of great practical importance, the 3 years in which these studies were conducted must be recognized as only a small sample of years and therefore inadequate to demonstrate clearly the effects of season on yields and grades of sweetpotatoes. It is of interest to determine, if possible, whether in these studies there were significant effects of locations independent of years and of years independent of locations on root yields. To this end data from the four locations in 1940 were studied in combined analyses and location variance was compared with that of replications within locations as error. On this basis significant yield differences among locations for both the No. 1 grade and the total yields were indicated. However, when the data from the four locations for 1941 and 1942 were analyzed together and variances for location and for year were compared with those for blocks within locations and years as error, no significance for either No. 1 grade or total yield differences was demonstrated.

Height of Ridge

Ridge culture is generally used by sweetpotato growers in southern United States. However, the height of ridge employed varies greatly among producing districts. Texture of the soil and the amount and intensity of rainfall are important factors in determining the most desirable ridge height. For example, in the Sunset district of Louisiana, where silt loams are used and the rainfall is heavy, ridges are maintained relatively high and are spaced approximately 4 feet apart. On the Eastern Shore of Virginia, where sandy loams are used and the rainfall is only moderately heavy, the crop is grown on moderate ridges set a little more closely—often 3.5 feet apart. In some sweetpotato-growing districts with sandy soils in New Jersey and elsewhere only very low ridges are used and sometimes even flat culture is practiced. Despite the fact that ridges are generally employed in sweetpotato culture, only limited tests have been conducted to determine the optimum height of the ridge for this crop.

From 1925 to 1931, inclusive, the Georgia Coastal Plain Experiment Station at Tifton compared three types of culture: Level, standard ridge—about 8 inches high, and high ridge—about 12 inches high (*16*). The mean yields in bushels per acre of the marketable grades for the 7 years were 118.7 for the high ridge, 102.2 for the standard ridge, and 99.6 for level culture. Although these yields indicate that high ridges are more favorable for the production of marketable yields than are low ridges, there is still need to determine the optimum height of the ridge on a regional basis.

In the present studies the heights of ridge compared were low, 3 to 4 inches; medium, 8 to 9 inches; and high, 14 to 15 inches. Average yields of roots obtained in the separate tests at different locations and in homogeneous test results combined by years and locations are presented in table 6. In general, these data show that differences in height of ridge resulted in moderate differences in the yields of No. 1 and No. 2 grade and total roots but had little consistent effect on the yields of Jumbo roots; neither were yields of culls (data not presented) significantly altered. The data in table 6 indicate that highly significant increases in yields of No. 1 grade roots, resulting from use of high or medium ridges as compared with low ridges, occurred in all 3 years at Blackville and Tifton, in 1941 at Meridian, and in the combined 1941 and 1942 results at Blackville, Tifton, and Meridian. In several of these tests the No. 1 grade yields were significantly larger from the high-ridge treatment than from the medium-ridge. Similar trends in mean yields of the No. 1 grade usually occurred in the 1940 and 1942 tests at Meridian, in the three tests at Gilmer, and in the combined results for 1941 and 1942 at Gilmer; but the differences were not significant.

Variance analyses for the combined 1941 and 1942 individual-location data summarized in table 6 are given in table 7. For yields of the No. 1 grade at Blackville there were significant interactions of ridge heights with times of harvest and highly significant interactions with years and years × times of harvest. Thus, at this location both seasonal test factors, including differences in soil types, and the times of harvesting the crop materially influenced the magnitudes of No. 1 grade yield differences resulting from differences in ridge heights. There were no significant influences of the year and time-of-harvest factors on ridge performance at the other three locations.

When No. 1 grade yields for all locations combined in 1940 and for all locations in 1941 and 1942 combined were analyzed, highly significant successive yield increases with successive increases in ridge heights were demonstrated. Thus, over-all average yield increases of 14.8 and 8.2 bushels per acre and of 20.5 and 5.9 bushels per acre were found in 1940 and in 1941 and 1942 combined, respectively, as the ridge height was increased from low to medium and from medium to high. Highly significant interactions of ridge heights with locations for both 1940 and 1941 and 1942 combined and with years × locations in 1941 and 1942 combined are indicated in the variance data summarized in table 8. Both location and season are therefore important factors in determining the differences in prime-root yields to be expected with different ridge heights.

TABLE 6.—*Effect of ridge height on grades and mean yields per acre of Porto Rico sweetpotatoes grown at 4 locations in 3 years*

Location and year	Roots of indicated grade grown with designated ridge height (and L. S. D.[1])													
	Jumbo			No. 1				No. 2			Total [2]			
	High	Medium	Low	High	Medium	Low	L. S. D.	High	Medium	Low	High	Medium	Low	L. S. D.
Blackville:	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1940	25.5	28.3	32.8	116.9	93.3	64.2	10.4**	120.9	102.4	84.5	311.5	257.4	210.1	18.1**
1941	29.5	42.6	31.2	179.9	163.7	146.2	9.1**	45.6	40.0	40.0	276.8	266.3	235.7	11.9**
1942	15.7	15.5	19.0	156.9	167.5	132.2	9.8**	74.0	65.9	59.4	272.5	274.8	233.3	13.5**
Mean (1941 and 1942)	22.6	29.1	25.1	168.4	165.6	139.2	6.6**	59.8	53.0	49.7	274.6	270.5	234.5	8.7**
Tifton:														
1940	2.1	.0	.2	92.8	91.5	64.6	7.6**	41.4	32.9	21.3	184.5	169.3	122.8	11.1**
1941	3.8	5.9	5.9	185.0	151.7	124.4	13.1**	28.5	26.1	22.1	272.7	252.9	234.6	13.1**
1942	1.0	1.0	.1	121.5	103.6	65.9	12.3**	45.9	37.2	29.2	213.1	198.0	157.6	17.7**
Mean (1941 and 1942)	2.4	3.4	3.0	153.3	127.7	95.1	8.8**	37.2	31.6	25.7	242.9	225.4	196.1	10.2**
Meridian:														
1940	7.4	5.8	4.4	61.5	57.4	54.5	(3)	44.4	41.6	40.9	131.7	121.5	116.3	10.6*
1941	5.6	6.3	4.1	117.0	119.3	95.6	10.2**	53.9	53.5	46.9	220.8	219.7	189.7	14.1**
1942	4.5	5.6	5.6	127.1	139.0	124.3	(3)	48.4	50.3	44.6	226.1	235.5	209.7	16.8*
Mean (1941 and 1942)	5.1	6.0	4.8	122.1	129.1	110.0	8.9**	51.2	51.9	45.7	223.4	227.6	199.7	10.7**

Gilmer:														
1940	16. 0	11. 4	10. 1	79. 8	76. 2	75. 9	(3)	123. 5	119. 0	107. 6	274. 0	263. 5	249. 7	15. 9**
1941	12. 3	7. 7	5. 6	68. 6	74. 3	71. 0	(3)	133. 2	132. 5	138. 2	248. 7	246. 6	250. 6	(3)
1942	4. 2	4. 3	4. 4	119. 8	109. 6	105. 2	(3)	68. 1	64. 2	69. 3	227. 8	215. 2	219. 0	(3)
Mean (1941 and 1942)	8. 3	6. 0	5. 0	94. 2	91. 9	88. 1	(3)	100. 6	98. 3	103. 8	238. 3	230. 9	234. 8	(3)
4 locations combined:														
1940	------	------	------	87. 8	79. 6	64. 8	4. 5**	------	------	------	------	(4)	------	------
1941 and 1942	------	------	------	134. 5	128. 6	108. 1	4. 3**	------	------	------	244. 8	238. 6	216. 2	5. 8**
Tifton, Meridian, and Gilmer combined (1940)	------	------	------	------	------	------	------	------	------	------	196. 7	184. 8	162. 9	7. 1**

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*Variances significant at 5-percent level.

**Variances significant at 1-percent level.

[1] Least significant difference between ridge heights at 5-percent level.

[2] Includes cull yields not shown in table.

[3] Difference not significant at 5-percent level.

[4] Data heterogeneous if combined for all 4 locations.

Table 7.—*Analyses of variances for the combined 1941 and 1942 data for separate locations summarized in table 6*

Source of variation	Degrees of freedom	Blackville		Tifton		Meridian		Gilmer	
		Variance	*F* value	Variance	*F* value	Variance	*F* value	Variance	*F* value
No. 1 grade yields:									
Ridge heights	2	16, 617. 06	48. 90**	54, 324. 97	89. 45**	5, 994. 53	9. 57**	602. 15	0. 71
Ridge heights × years	2	2, 981. 44	8. 77**	996. 87	1. 64	1, 392. 50	2. 22	1, 448. 37	1. 72
Ridge heights × times of harvest	6	889. 11	2. 62*	1, 040. 25	1. 71	1, 266. 63	2. 02	120. 07	. 14
Ridge heights × times of harvest × years	6	1, 267. 29	3. 73**	441. 85	. 73	558. 90	. 89	202. 33	. 24
Error	48	339. 83		607. 29		626. 00		844. 05	
Total	64	1, 069. 50		2, 323. 22		871. 49		727. 33	
Total yields:									
Ridge heights	2	31, 234. 95	51. 61**	35, 764. 81	43. 29**	14, 464. 91	15. 93**	861. 80	. 43
Ridge heights × years	2	770. 68	1. 27	2. 208. 71	2. 67	918. 27	1. 01	590. 92	. 29
Ridge heights × times of harvest	6	662. 70	1. 09	1, 249. 73	1. 51	2, 287. 67	2. 52*	1, 135. 62	. 56
Ridge heights × times of harvest × years	6	739. 45	1. 22	915. 14	1. 11	848. 56	. 93	874. 02	. 43
Error	48	605. 25		826. 19		907. 82		2, 019. 16	
Total	64	1, 585. 54		2, 009. 28		1, 455. 62		1, 748. 18	

*Significant at 5-percent level.
**Significant at 1-percent level.

Table 8.—*Analyses of variances for combined location data summarized in table 6*

Source of variation	Degrees of freedom	Variance	*F* value
No. 1 grade yields:			
4 locations (1940):			
Ridge heights	2	17, 392. 85	53. 09**
Ridge heights × locations	6	4, 555. 65	13. 90**
Ridge heights × times of harvest	6	414. 41	1. 26
Ridge heights × nitrogen levels	2	123. 34	. 38
Ridge heights × locations × times of harvest	18	476. 48	1. 45
Ridge heights × locations × nitrogen levels	6	577. 41	1. 76
Ridge heights × times of harvest × nitrogen levels	6	231. 12	. 71
Ridge heights × locations × times of harvest × nitrogen levels	18	544. 07	1. 66
Error	192	327. 58	
Total	256	589. 27	
4 locations (1941 and 1942):			
Ridge heights	2	48, 872. 73	80. 87**
Ridge heights × years	2	1, 501. 51	2. 48
Ridge heights × times of harvest	6	502. 07	. 83
Ridge heights × locations	6	9, 555. 33	15. 81**
Ridge heights × years × times of harvest	6	419. 39	. 69
Ridge heights × years × locations	6	1, 843. 38	3. 05**
Ridge heights × times of harvest × locations	18	938. 00	1. 55
Ridge heights × years × times of harvest × locations	18	660. 03	1. 09
Error	192	604. 29	
Total	256	1, 247. 89	
Total yields:			
Tifton, Meridian, and Gilmer (1940):			
Ridge heights	2	28, 289. 22	45. 21**
Ridge heights × locations	4	5, 796. 12	9. 25**
Ridge heights × times of harvest	6	565. 42	. 90
Ridge heights × nitrogen levels	2	722. 49	1. 15
Ridge heights × locations × times of harvest	12	472. 92	. 76
Ridge heights × locations × nitrogen levels	4	772. 17	1. 23
Ridge heights × times of harvest × nitrogen levels	6	509. 29	. 81
Ridge heights × locations × times of harvest × nitrogen levels	12	614. 18	. 98
Error	144	625. 77	
Total	192	1, 010. 01	

**Significant at 1-percent level.

TABLE 8.—*Analyses of variances for combined location data summarized in table 6*—Continued

Source of variation	Degrees of freedom	Variance	*F* value
Total yields—Continued			
4 locations (1941 and 1942):			
Ridge heights	2	57, 624. 86	52. 89**
Ridge heights × years	2	863. 19	. 79
Ridge heights × times of harvest	6	789. 53	. 72
Ridge heights × locations	6	8, 240. 54	7. 56**
Ridge heights × years × times of harvest	6	933. 75	. 86
Ridge heights × years × locations	6	1, 201. 80	1. 10
Ridge heights × times of harvest × locations	18	1, 513. 17	1. 39
Ridge heights × years × times of harvest × locations	18	816. 70	. 75
Error	192	1, 089. 60	
Total	256	1, 699. 66	

**Significant at 1-percent level.

In general, trends in total yields with differences in ridge heights were very similar to those for the No. 1 grade. In 10 of the 12 individual tests and 3 of the 4 locations for 1941 and 1942 combined, significant or highly significant average total yield increases occurred when the ridge height was increased from low to medium or high. Differences in yields between low and medium and medium and high ridges were usually, but not always, statistically significant. At Gilmer in 1941, 1942, and 1941 and 1942 combined, differences in yields due to ridge heights lacked statistical significance. When data for Tifton, Meridian, and Gilmer combined for 1940 alone and those for all 4 locations for 1941 and 1942 combined were analyzed, there were average increases in total yields of 21.9 and 11.9 bushels per acre and 22.4 and 6.2 bushels per acre, respectively, as ridge sizes were increased from low to medium and from medium to high.

NITROGEN LEVEL

It is well known that for many horticultural crops in most places the supply of nitrogen is more likely to be deficient than that of other nutrients in the soil. Furthermore, the effects of varying the supply of nitrogen on yields and quality of most of the major crops are fairly well understood. With few exceptions there appears to be little danger of reducing yields or impairing quality by growing vegetable crops on high-nitrogen soils or by applying substantial amounts of nitrogenous fertilizer within the limits of present commercial practices; in fact, the converse is generally true. On the other hand, the sweetpotato is usually considered an exception because it requires relatively little nitrogen for its best development and because large amounts of nitrogen applied to the crop will force an excessive vine growth at the expense of root yields and may impair grade and color of the roots.

In these studies two levels of available nitrogen were compared: a relatively high level, varying from 48 to 100 pounds per acre, and a low one, varying from 10 to 20 pounds per acre. (See table 3 for specific applications made.) Although effects on total yields were of interest, those on grade and quality of root color were especially sought.

The mean yields of No. 1 grade, No. 2 grade, Jumbo, and all grades combined obtained with the two nitrogen levels at each location in each of the 3 years and for 1941 and 1942 combined are shown in table 9. With few exceptions the mean No. 1 grade, Jumbo, and total yields produced with the high-nitrogen treatment were higher than those produced with the low-nitrogen treatment. The mean yields of the No. 2 grade were also higher with the high-nitrogen level in all 3 years at Blackville, in 1941 at Meridian, and in 1942 at Tifton and Gilmer, but they were lower than those with the low-nitrogen level in the remaining tests at Tifton, Meridian, and Gilmer. The most outstanding exceptions to the generally increased yields with the high-nitrogen levels were obtained at Meridian in 1940 and 1942, when the mean yields of the separate grades and totals of the low-nitrogen-level plots exceeded those of the high-nitrogen-level plots. Although the No. 1 grade and total yield differences at Meridian in 1940 lacked statistical significance, those in 1942 were highly significant.

Variance data for the combined 1941 and 1942 No. 1 grade and total yields at the four locations are presented in table 10. Highly significant variances (when referred to residual error) due to nitrogen levels are indicated for No. 1 grade yields at all four locations and for total yields at all locations except Meridian. At all four locations for both No. 1 grade and total yields there were highly significant interactions of nitrogen levels and years. Despite the significant interaction between nitrogen and years, the high-nitrogen level produced significantly higher yields. Thus for the conditions under which the tests were conducted the high-nitrogen level can be recommended with a reasonable degree of confidence.

Data for average No. 1 grade and total yields for 1940 alone and for 1941 and 1942 together for all four locations combined are also included in table 9. Variance data for these combined results are summarized in table 11. In all cases there were highly significant yield increases as a result of the high-nitrogen-level treatments. The variance data also show significant interactions of nitrogen levels and locations and of these factors with years (when referred to error variance). Thus the environmental factors associated with locations as well as those associated with seasons are responsible for variable yield responses to the two nitrogen levels.

TABLE 9.—*Effect of nitrogen level on grades and mean yields per acre of Porto Rico sweetpotatoes grown at 4 locations in 3 years*

Location and year	Roots of indicated grade grown with designated nitrogen level (and L. S. D.[1])									
	Jumbo		No. 1			No. 2		Total [2]		
	High	Low	High	Low	L. S. D.	High	Low	High	Low	L. S. D.
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Blackville:										
1940	34.3	23.5	101.9	81.1	11.3**	111.3	94.0	282.1	237.9	21.5**
1941	46.4	22.5	178.8	147.7	7.9**	45.0	38.8	289.8	229.4	9.0**
1942	19.0	14.5	155.7	148.7	(3)	67.9	64.9	266.5	253.9	10.6*
Mean (1941 and 1942)	32.7	18.5	167.3	148.2	5.5**	56.4	51.8	278.2	241.6	6.8**
Tifton:										
1940	1.4	.1	91.8	74.1	10.5**	31.2	32.6	168.5	149.4	13.0**
1941	7.4	3.0	157.8	149.6	6.8*	22.6	28.5	260.8	245.9	9.2**
1942	.9	.4	118.7	75.3	7.7**	39.7	35.2	218.1	161.1	8.9**
Mean (1941 and 1942)	4.2	1.7	138.2	112.4	4.9**	31.1	31.9	239.4	203.5	5.8**
Meridian:										
1940	5.0	6.7	55.3	60.4	(3)	41.6	43.1	118.1	128.3	(3)
1941	7.1	3.6	126.0	95.3	6.1**	52.1	50.8	223.4	196.7	7.5**
1942	5.0	5.5	121.3	138.9	7.8**	44.0	51.6	207.7	239.8	8.8**
Mean (1941 and 1942)	6.1	4.5	123.7	117.1	4.7**	48.0	51.2	215.5	218.3	(3)

Gilmer:										
1940	13. 6	11. 4	86. 4	68. 2	9. 7**	110. 0	123. 5	260. 7	264. 3	(3)
1941	9. 9	7. 2	74. 5	68. 1	(3)	132. 6	136. 8	253. 5	243. 8	(3)
1942	6. 4	2. 2	129. 3	93. 8	11. 1**	75. 5	58. 8	247. 8	193. 5	11. 8**
Mean (1941 and 1942)	8. 1	4. 7	101. 9	80. 9	(4)	104. 1	97. 8	250. 6	218. 6	7. 9**
4 locations combined:										
1940			83. 9	71. 0	4. 9**			207. 3	195. 0	7. 5**
1941 and 1942			132. 8	114. 7	2. 7**			245. 9	220. 5	3. 4**

*Variances significant at 5-percent level.

**Variances significant at 1-percent level.

[1] Least significant difference between nitrogen levels at 5-percent level.

[2] Includes cull yields not shown in table.

[3] Difference not significant at 5-percent level.

[4] Data heterogeneous if combined for 1941 and 1942.

TABLE 10.—*Analyses of variances for the combined 1941 and 1942 data for separate locations summarized in table 9*

Source of variation	Degrees of freedom	Blackville		Tifton		Meridian		Gilmer	
		Variance	*F* value	Variance	*F* value	Variance	*F* value	Variance	*F* value
No. 1 grade yields:									
Nitrogen levels	1	17, 450. 33	48. 07**	31, 940. 01	111. 57**	2, 093. 38	7. 93**	21, 014. 16	53. 20**
Nitrogen levels × years	1	6, 999. 17	19. 28**	14, 967. 41	52. 28**	28, 053. 65	106. 33**	10, 196. 42	25. 81**
Nitrogen levels × times of harvest	3	798. 78	2. 20	546. 74	1. 91	945. 67	3. 58*	718. 44	1. 82
Nitrogen levels × ridge heights	2	443. 60	1. 22	1, 277. 17	4. 46*	91. 12	. 35	98. 23	. 25
Nitrogen levels × times of harvest × ridge heights	6	364. 47	1. 00	252. 73	. 88	236. 03	. 89	742. 91	1. 88
Nitrogen levels × times of harvest × years	3	491. 76	1. 35	550. 10	1. 92	1, 186. 51	4. 50**	162. 37	. 41
Nitrogen levels × years × ridge heights	2	453. 52	1. 25	289. 43	1. 01	1, 002. 60	3. 80*	127. 59	. 32
Nitrogen levels × years × ridge heights × times of harvest	6	478. 26	1. 32	748. 97	2. 62	586. 01	2. 22*	1, 125. 80	2. 85*
Error	72	363. 02	--------	286. 27	--------	263. 83	--------	395. 01	--------
Total	96	672. 94	--------	832. 81	--------	652. 68	--------	770. 39	--------
Total yields:									
Nitrogen levels	1	64, 095. 24	113. 86**	62, 100. 36	150. 93**	348. 89	1. 47	49, 171. 64	65. 02**
Nitrogen levels × years	1	27, 368. 98	48. 62**	21, 237. 05	51. 62**	41, 465. 73	174. 36**	23, 894. 04	31. 60**
Nitrogen levels × times of harvest	3	561. 83	. 99	1, 438. 85	3. 50*	612. 89	2. 58	2, 795. 61	3. 70
Nitrogen levels × ridge heights	2	728. 69	1. 29	2, 624. 44	6. 38*	312. 33	1. 31	233. 79	. 31
Nitrogen levels × times of harvest × ridge heights	6	828. 93	1. 47	1, 469. 72	3. 57**	171. 33	. 72	730. 30	. 97
Nitrogen levels × times of harvest × years	3	145. 21	. 26	1, 181. 74	2. 87*	310. 94	1. 31	634. 47	. 84
Nitrogen levels × years × ridge heights	2	885. 02	1. 57	72. 90	. 18	1, 132. 42	4. 76*	152. 79	. 20
Nitrogen levels × years × ridge heights × times of harvest	6	592. 89	1. 05	1, 829. 58	4. 45**	1, 449. 39	6. 09**	1, 228. 77	1. 62
Error	72	562. 95	--------	411. 45	--------	237. 81	--------	756. 22	--------
Total	96	1, 519. 56	--------	1, 520. 94	--------	836. 04	--------	1, 565. 94	--------

*Significant at 5-percent level. **Significant at 1-percent level.

TABLE 11.—*Analyses of variances for the combined location data summarized in table 9*

Source of variation	Degrees of freedom	No. 1 grade yields		Total yields	
		Variance	*F* value	Variance	*F* value
4 locations (1940):					
Nitrogen levels	1	15, 983. 98	27. 68**	14, 676. 96	10. 87**
Nitrogen levels × locations	3	3, 497. 28	6. 06**	14, 587. 36	10. 81**
Nitrogen levels × times of harvest	3	197. 39	. 34	108. 31	. 08
Nitrogen levels × locations × times of harvest	9	612. 99	1. 06	924. 10	. 68
Error	48	577. 54		1, 349. 71	
Total	64	942. 28		2, 060. 47	
4 locations (1941 and 1942):					
Nitrogen levels	1	62, 450. 27	173. 33**	124, 439. 15	215. 95**
Nitrogen levels × years	1	599. 48	1. 66	1, 186. 74	2. 06
Nitrogen levels × locations	3	3, 349. 21	9. 30**	17, 105. 72	29. 69**
Nitrogen levels × times of harvest	3	309. 56	. 86	2, 646. 78	4. 59**
Nitrogen levels × ridge heights	2	370. 14	1. 03	853. 30	1. 48
Nitrogen levels × locations × years	3	20, 014. 06	55. 55**	37, 579. 60	65. 22**
Nitrogen levels × times of harvest × years	3	219. 92	. 61	893. 46	1. 55
Nitrogen levels × ridge heights × years	2	95. 70	. 27	848. 10	1. 47
Nitrogen levels × times of harvest × locations	9	900. 05	2. 50**	916. 35	1. 59
Nitrogen levels × ridge heights × locations	6	513. 31	1. 42	1, 008. 63	1. 75
Nitrogen levels × ridge heights × times of harvest	6	594. 41	1. 65	1, 183. 22	2. 05
Nitrogen levels × years × locations × times of harvest	9	676. 37	1. 88	464. 09	. 81
Nitrogen levels × years × locations × ridge heights	6	521. 64	1. 45	471. 70	. 82
Nitrogen levels × locations × times of harvest × ridge heights	18	333. 87	. 93	674. 59	1. 17
Nitrogen levels × years × times of harvest × ridge heights	6	284. 62	. 79	1, 849. 90	3. 21**
Nitrogen levels × years × times of harvest × locations × ridge heights	18	376. 40	1. 04	65. 16	. 11
Error	288	360. 29		576. 23	
Total	384	723. 64		1, 360. 61	

**Significant at 1-percent level.

Time of Harvest

The optimum time for harvesting the main crop of Porto Rico sweetpotatoes has not been definitely determined. Two groups of important and somewhat opposing factors are involved in establishing this period: namely, the influence of the length of the growing season on the yield and grade of the roots and the effects of weather at and immediately before harvest on the curing and keeping properties of the roots. Conceivably, the longer the growing season, with other factors favorable, the greater should be the yield. Conceivably also, the cold weather which often occurs at the end of the growing season may predispose the roots to losses in storage. Many growers delay the harvest until cold weather begins or the vines have been touched by frost. Tests at the Georgia Coastal Plain Experiment Station at Tifton (*16*) indicate that there is no practical advantage in delaying the harvest until the weather gets cold. Workers at the Alabama Agricultural Experiment Station (*12*) concluded from 1 year's work that harvesting of sweetpotatoes immediately after frost has killed the vines greatly predisposes the roots to losses in storage.

Although delayed harvest after frost may impair keeping quality, wide variations in the degree of impairment have been observed by various workers under different conditions. Are increases in yields, particularly of the marketable grades, sufficiently high to warrant delaying the harvest to within a few days of the first killing frost or should the harvest occur 2 or 3 weeks before frost occurs when reasonably warm weather is assured and curing processes and harvesting operations are facilitated? Because of the great practical significance of this question, studies on effect of time of harvest on yields and grades of the storage roots were included in these investigations.

The data in table 12 show the mean yield of the No. 1 grade and of all grades for each harvest in each of the 3 years at the four locations, the mean yield of the No. 1 grade for all locations combined in 1940 and for all locations combined in 1941 and 1942, and the mean yield of all grades for certain locations combined in 1940 and for certain locations combined in 1941 and 1942. Variance analyses for combined years and locations summarized in this table are presented in tables 13 and 14.

Highly significant yield differences among harvests are evident in most cases for both No. 1 grade and total yields. As a rule, at Blackville, Tifton, and Meridian in individual years and when 1941 and 1942 results were combined, there were consistent and significant successive increases in these yields from the first through the third harvest and in many cases yields, especially the total, continued to increase through the fourth. At Gilmer, however, there was a tendency for average No. 1 grade yields to decrease with the successive delays in digging. At this location, the differences in No. 1 yields among harvests were not statistically significant (1940, 1942, and 1941 and 1942 combined) but were highly significant in 1941. The variability or even decrease in Gilmer yields with successive harvest delays presents a rather interesting and unusual case of the influence of soil type on grade of the roots. At this location the soil type is a Bowie fine sand and was deficient in organic matter and crusted badly. The plants in this soil produced rough roots. As a result, potatoes which met the requirements of the No. 1 grade in early harvests failed to meet these requirements in later harvests. As indicated by the data, the longer the crust remained the greater was the proportion of roots falling in the No. 2 grade. The effect of time of harvest on total yields at Gilmer was similar to that obtained at the other three locations.

The data show rather large differences in the No. 1 grade and total yields for successive harvests among years at single locations and among locations in one or more seasons. The significant interactions of times of harvest with years at Meridian and Gilmer shown in table 13 and with locations, with years, and with locations × years, indicated in table 14, suggest that environmental factors associated with season and location have considerable influence on yield differences to be expected with different times of harvest. Nevertheless, the yields of No. 1 grade for all locations combined for 1940 show successive increases of about 39 percent, 14 percent, and 25 percent, respectively, with the three successive delays in harvest. Further, the corresponding data for 1941 and 1942 for the four locations combined show successive increases of approximately 19 percent between the first and second harvests and 21 percent between the second and third harvests, respectively, but a decrease of about 5 percent between the third and the fourth. Similar percentage yield increases between successive harvests were also noted when homogeneous results for total yields were averaged for locations for 1940 and for 1941 and 1942 combined.

The proportionate parts of the total yields contributed by the Jumbo, No. 1, No. 2, and cull grades in each of the tests are shown in table 15. In general, Jumbo roots constituted a relatively small percentage of the total yields. In fact, only at Blackville were any appreciable proportions of them produced in the 3 years. The No. 1 and No. 2 grade roots together constituted the largest part of the total yields. Although the relative proportions of No. 1 and No. 2 grades varied from year to year and at different locations, the most common trend under good growing conditions was a relative increase in No. 1 grade and a more or less corresponding decrease in No. 2 grade (and sometimes in culls) as the harvests were delayed, at least up to the third harvest period. The results for Gilmer for all 3 years and those for Blackville in 1942, however, showed trends the reverse of this.

In general, it appears from these studies that under average favorable soil and other conditions when plantings are made no earlier than in these studies successively larger yields of No. 1 grade and total roots (as well as of Jumbo, No. 2 grade, and cull roots) can be expected at successive harvests up to the time of the first killing frost. As harvest is delayed up to this time, there is usually a relatively greater weight increase in No. 1 grade yields than in other grades.

These results confirm the common belief that for the maximum yield and percentage of No. 1 grade roots the harvest should be made as near the first-killing-frost date as practicable without unduly risking dangers from cold injury during subsequent handling or storage.

Table 12.—*Effect of time of harvest on mean No. 1 grade and total yields per acre of Porto Rico sweetpotatoes at 4 locations in 3 years*

Location and year	Roots of indicated grade for designated harvest (and L. S. D.[1])									
	No. 1					Total				
	First	Second	Third	Fourth	L. S. D.	First	Second	Third	Fourth	L. S. D.
Blackville:	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1940	45. 6	82. 5	101. 2	136. 8	10. 7**	189. 4	266. 0	263. 6	321. 1	28. 1**
1941	136. 1	165. 5	191. 4	160. 1	15. 2**	207. 7	238. 6	266. 4	325. 7	16. 6**
1942	145. 2	148. 8	167. 3	147. 4	17. 3*	204. 4	240. 8	282. 7	312. 8	25. 3**
Mean (1941 and 1942)	140. 6	157. 2	179. 4	153. 8	13. 9**	206. 1	239. 7	274. 6	319. 2	15. 9**
Tifton:										
1940	46. 8	67. 7	103. 3	114. 2	14. 3**	106. 5	142. 1	179. 6	207. 5	17. 3**
1941	119. 2	151. 4	177. 3	166. 8	17. 9**	200. 8	227. 6	281. 5	303. 4	8. 7**
1942	82. 3	85. 3	115. 7	104. 7	(2)	157. 1	175. 8	215. 6	209. 8	40. 4*
Mean (1941 and 1942)	100. 8	118. 4	146. 5	135. 7	17. 9**	178. 9	201. 7	248. 5	256. 6	(3)
Meridian:										
1940	30. 7	51. 2	53. 7	95. 7	21. 4**	80. 0	114. 5	134. 4	163. 9	16. 1**
1941	74. 5	99. 9	130. 2	138. 0	38. 4*	145. 9	202. 3	245. 8	246. 1	51. 7**
1942	26. 4	103. 1	187. 7	203. 2	29. 6**	100. 1	204. 8	272. 0	318. 2	36. 7**
Mean (1941 and 1942)	50. 5	101. 5	159. 0	170. 6	32. 1**	123. 0	203. 6	258. 9	282. 2	32. 2**

Gilmer:										
1940	85. 8	88. 2	70. 5	64. 6	(2)	254. 8	279. 6	266. 2	245. 3	(2)
1941	104. 6	53. 3	68. 7	58. 6	23. 8**	203. 3	231. 8	276. 0	283. 3	39. 3**
1942	104. 7	134. 5	100. 2	106. 8	(2)	156. 9	213. 2	260. 1	252. 5	18. 0**
Mean (1941 and 1942)	104. 6	93. 9	84. 4	82. 7	(2)	180. 1	222. 5	268. 0	267. 9	31. 4**
4 locations (1940)	52. 2	72. 4	82. 2	102. 8	8. 8**	(3)				
4 locations (1941 and 1942)	99. 1	117. 7	142. 3	135. 7	7. 3**	(3)				
Blackville, Tifton, and Meridian (1940)						125. 3	174. 2	192. 5	230. 8	10. 0**
Tifton, Meridian, and Gilmer (1941 and 1942)						160. 7	209. 3	258. 5	268. 9	6. 3**
7 tests (Blackville, Meridian, and Gilmer, 1941 and 1942, and Tifton, 1942)						167. 9	215. 3	259. 8	278. 3	10. 8**

*Variances significant at 5-percent level.

**Variances significant at 1-percent level.

[1] Least significant difference between harvests at 5-percent level.

[2] Difference not significant at 5-percent level.

[3] Data heterogeneous if combined for the years and locations indicated.

TABLE 13.—*Analyses of variances for the combined 1941 and 1942 data for separate locations summarized in table 12*

Source of variation	Degrees of freedom	Blackville		Tifton		Meridian		Gilmer	
		Variance	*F* value	Variance	*F* value	Variance	*F* value	Variance	*F* value
No. 1 grade yields:									
Times of harvest	3	12, 436. 95	11. 90**	19, 359. 67	11. 16**	148, 045. 57	26. 45**	4, 909. 84	2. 93
Times of harvest × years	3	2, 440. 63	2. 33	2, 141. 51	1. 23	33, 458. 49	5. 98**	13, 688. 39	8. 17**
Error	18	1, 045. 32		1, 735. 33		5, 597. 98		1, 675. 34	
Total	24	2, 643. 68		3, 989. 14		26, 886. 48		3, 581. 28	
Total yields:									
Times of harvest	3	112, 674. 72	82. 54**	(1)		240, 141. 29	42. 61**	85, 510. 37	15. 91**
Times of harvest × years	3	1, 783. 76	1. 31			28, 944. 68	5. 14**	2, 329. 35	. 43
Error	18	1, 365. 13				5, 636. 29		5, 374. 89	
Total	24	15, 331. 16				37, 862. 97		15, 011. 12	

**Significant at 1-percent level.

[1] Data heterogeneous if combined for 1941 and 1942.

TABLE 14.—*Analyses of variances for the combined location data summarized in table 12*

Source of variation	Degrees of freedom	Variance	*F* value
No. 1 grade yields:			
4 locations (1940):			
Times of harvest	3	42, 524. 10	47. 51**
Times of harvest × locations	9	12, 213. 41	13. 64**
Error	36	895. 11	
Total	48	5, 619. 16	
4 locations (1941 and 1942):			
Times of harvest	3	72, 163. 72	57. 71**
Times of harvest × years	3	7, 109. 10	5. 69**
Times of harvest × locations	9	37, 529. 43	30. 01**
Times of harvest × years × locations	9	14, 920. 53	11. 93**
Error	48	1, 250. 36	
Total	72	10, 692. 86	
Total yields:			
Blackville, Tifton, and Meridian (1940):			
Times of harvest	3	138, 279. 71	154. 23**
Times of harvest × locations	6	4, 058. 88	4. 53**
Error	18	896. 56	
Total	27	16, 864. 06	
Tifton, Meridian, and Gilmer (1941 and 1942):			
Times of harvest	3	356, 644. 33	505. 48**
Times of harvest × years	3	6, 144. 45	8. 71**
Times of harvest × locations	6	17, 848. 41	25. 30**
Times of harvest × years × locations	6	15, 457. 43	21. 19**
Error	36	705. 56	
Total	54	24, 325. 94	
7 tests (Blackville, Meridian, and Gilmer, 1941 and 1942, and Tifton, 1942):			
Times of harvest	3	408, 365. 54	169. 17**
Times of harvest × tests	18	13, 609. 37	5. 64**
Error	42	2, 413. 94	
Total	63	24, 943. 67	

**Significant at 1-percent level.

TABLE 15.—*Proportions of the total yields of Porto Rico sweetpotatoes contributed by the separate grades of roots at 4 harvest periods at 4 locations in 3 years*

Location and year	Portion of total yield contributed by indicated grade for designated harvest															
	Jumbo				No. 1				No. 2				Cull			
	First	Second	Third	Fourth	First	Second	Third	Fourth	First	Second	Third	Fourth	First	Second	Third	Fourth
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Blackville:																
1940	3.3	7.9	10.0	19.2	24.1	31.0	38.4	42.6	54.1	46.5	36.7	27.4	18.5	14.6	14.9	10.8
1941	2.8	12.6	12.1	21.4	65.5	69.3	71.9	49.2	23.8	9.1	11.4	20.2	7.9	9.0	4.6	9.2
1942 [1]	3.9	7.7	6.9	6.6	71.1	61.8	59.2	47.1	13.1	17.7	27.3	38.1	11.4	10.3	5.4	7.8
Tifton:																
1940	.0	.5	.1	1.0	43.9	47.6	57.5	55.1	20.0	20.4	19.9	20.0	36.1	31.5	22.5	23.9
1941	3.3	2.5	1.8	1.1	59.4	66.5	63.0	55.0	12.8	8.0	7.6	12.1	24.5	23.0	27.6	31.8
1942	.4	.9	.1	.2	52.4	48.5	53.7	49.9	17.9	20.1	18.5	22.2	29.3	30.5	27.7	27.7
Meridian:																
1940	.3	3.9	2.4	9.4	38.4	44.7	40.0	58.4	47.0	37.9	50.2	12.7	14.3	13.5	7.4	19.5
1941	.4	1.7	4.7	2.3	51.1	49.4	53.0	56.1	22.8	27.3	24.8	22.9	25.7	21.6	17.5	18.7
1942	1.2	.9	2.7	3.3	26.4	50.4	69.0	63.9	27.8	28.3	16.2	19.2	44.6	20.4	12.1	13.6
Gilmer:																
1940	5.9	4.9	3.8	4.4	33.2	31.6	26.5	26.3	40.2	42.8	47.9	47.1	20.7	20.7	21.8	22.2
1941	6.6	2.1	2.2	3.5	51.5	23.0	24.9	20.7	24.7	59.4	62.0	63.3	17.2	15.5	10.9	12.5
1942	.5	1.6	3.5	1.5	66.7	63.1	38.5	42.3	18.7	21.6	43.1	32.2	14.1	13.7	14.9	24.0

[1] Cut-root weights for separate grades not included in yields from which 1942 Blackville percentages were calculated.

RELATION OF VARIOUS FACTORS TO ROOT CUTTING DURING HARVEST

Cutting and bruising of the roots during harvest, either by contact with digging equipment or in handling, frequently lead to serious impairment of appearance and market quality and often to heavy losses from rots. Prompt curing of injured roots must be accomplished if infection of wounds by rot-producing micro-organisms is to be avoided or kept at a minimum. Plant production is also reduced when such roots are subsequently bedded. It is highly important, therefore, that injuries during harvest be reduced as far as possible.

Investigations conducted at the Mississippi Agricultural Experiment Station (*13*) demonstrated that two-horse plows and tractor-drawn diggers cut fewer roots than single-horse plows or small middlebusters. There are other factors that influence the amount of harvest injuries on which there is very little experimental evidence for making recommendations. Among such factors are direct or indirect influences of soil characteristics, fertility levels, times of harvest, weather variations, and types of ridge culture.

In the present studies the effects of the several factors on the amounts of root cutting during harvest were investigated and evaluated. Mean quantities of roots cut per acre in each test and in tests combined for years and locations are presented in table 16. Because the over-all root yields varied considerably among locations and years and because equal quantities of cut roots might actually represent quite different proportions of the crop in different tests, the cut-root yields for the several tests are presented also in table 17 as percentages of total root yields.

Location and Season

The data show considerable differences in the quantities of cut roots among locations and among years at single locations. In general, large quantities were cut at Tifton in 1941 and 1942 and at Gilmer in 1940; moderately large quantities were cut at Meridian in 1940 and 1941 and at Gilmer in 1941; and small quantities were cut at Blackville in each of the 3 years and at Meridian and Gilmer in 1942.

The reasons for the consistently low quantities of cut roots at Blackville, the consistently high quantities of cut roots at Tifton, and the inconsistencies in quantities of cut roots among years and among harvests in certain years at Meridian and Gilmer are not definitely known. Undoubtedly factors contributing to the differences in quantities of cut roots are variations in types of plow, in depths of setting and operating the plow, in soil type, and in methods of soil preparation.

In some tests the use of shaker-type digging plows, on which the rod wings are agitated by an eccentric wheel located directly beneath them, proved more or less unsatisfactory, and the amount of cutting injury resulting from their use was usually excessive regardless of the soil conditions or type of culture involved. At Meridian team-drawn middlebusters were more satisfactory than shaker-type plows

TABLE 16.—*Influence of location and year (test), time of harvest, ridge height, and nitrogen level on mean quantities of Porto Rico sweetpotato roots cut per acre*

Location and year	Roots cut in relation to factor indicated (and L. S. D.[1])												
	Test	Time of harvest					Ridge height				Nitrogen level		
		First	Second	Third	Fourth	L. S. D.	High	Medium	Low	L. S. D.	High	Low	L. S. D.
Blackville:	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1940	3.5	5.0	2.5	3.9	2.6	(2)	3.7	3.8	3.0	(2)	3.8	3.3	(2)
1941	2.7	7.0	.5	1.7	1.6	2.7**	2.9	2.3	2.9	(2)	3.0	2.4	(2)
1942	2.9	1.3	6.0	3.4	.9	3.3*	2.0	2.6	4.1	1.3	3.2	2.6	(2)
Mean (1941 and 1942)	2.8	4.2	3.3	2.6	1.2	2.0*	2.5	2.5	3.5	(2)	3.1	2.5	(2)
Tifton:[3]													
1941	21.4	24.0	22.9	25.9	12.7	(2)	8.6	19.3	36.2	5.2**	22.1	20.6	(2)
1942	17.1	14.3	20.7	20.3	13.2	(2)	9.0	17.5	24.9	9.9*	19.1	15.1	(2)
Mean (1941 and 1942)	19.2	19.1	21.8	23.1	12.9	6.2*	8.8	18.4	30.6	3.5**	(4)	(4)	(4)
Meridian:													
1940	11.7	4.9	7.9	18.0	16.1	4.9**	10.0	12.1	13.1	(2)	11.0	12.4	(2)
1941	11.4	10.9	5.7	9.6	19.5	8.2*	6.3	11.1	16.7	3.8**	12.9	9.9	2.7*
1942	2.0	1.8	.9	4.7	.7	2.2**	.5	.8	4.8	1.8**	1.9	2.1	(2)
Mean (1941 and 1942)[4]													

Gilmer:													
1940	17. 8	20. 4	20. 8	11. 5	18. 5	(2)	14. 5	18. 6	20. 3	(2)	18. 3	17. 3	(2)
1941	9. 2	3. 8	3. 2	20. 5	9. 4	10. 4**	6. 8	9. 4	11. 6	(2)	10. 1	8. 3	(2)
1942	4. 0	3. 4	4. 0	2. 0	6. 6	3. 1*	2. 8	3. 9	5. 4	2. 0*	5. 0	3. 0	. 6**
Mean (1941 and 1942) [4]													
Blackville and Meridian combined (1940)		5. 0	5. 2	11. 0	9. 4	2. 9**	6. 8	8. 0	8. 0	(4)	7. 4	7. 9	(2)
Meridian, Tifton, and Gilmer combined (1941)		12. 9	10. 6	18. 7	13. 9	6. 5*	7. 2	13. 3	21. 5	2. 8**	15. 1	12. 9	1. 7*
Blackville (1941) and Blackville, Meridian, and Gilmer (1942) combined		3. 4	2. 9	3. 0	2. 4	(2)	2. 1	2. 4	4. 3	. 6**	3. 3	2. 5	. 5**

*Variances significant at 5-percent level.

**Variances significant at 1-percent level.

[1] Least significant difference at 5-percent level.

[2] Differences not significant at 5-percent level.

[3] No data gathered in 1940.

[4] Data heterogeneous if combined as indicated.

TABLE 17.—*Influence of location and year (test), time of harvest, ridge height, and nitrogen level on mean percentage*[1] *of Porto Rico sweetpotato roots cut*

Location and year	Roots cut in relation to factor indicated									
	Test	Time of harvest				Ridge height			Nitrogen level	
		First	Second	Third	Fourth	High	Medium	Low	High	Low
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Blackville:										
1940	1. 35	2. 64	0. 94	1. 48	0. 81	1. 19	1. 48	1. 43	1. 35	1. 39
1941	1. 04	3. 37	. 21	. 64	. 49	1. 05	. 86	1. 23	1. 04	1. 05
1942	1. 11	. 64	2. 49	1. 20	. 29	. 73	. 95	1. 76	1. 20	1. 02
Tifton:[2]										
1941	8. 46	11. 95	10. 06	9. 20	4. 19	3. 15	7. 63	15. 43	8. 47	8. 38
1942	9. 36	9. 10	11. 77	9. 42	6. 29	4. 22	8. 84	15. 80	8. 76	9. 37
Meridian:										
1940	9. 38	6. 13	6. 90	13. 4	9. 82	8. 60	9. 96	11. 26	9. 31	9. 66
1941	5. 43	7. 47	2. 82	3. 91	7. 92	2. 85	5. 05	8. 80	5. 77	5. 03
1942	. 91	1. 80	. 44	1. 73	. 22	. 22	. 34	2. 29	. 91	. 88
Gilmer:										
1940	6. 69	7. 88	7. 44	2. 18	7. 54	5. 29	7. 06	8. 13	7. 02	6. 55
1941	3. 70	1. 86	1. 38	7. 43	3. 32	2. 73	4. 81	4. 62	3. 98	3. 40
1942	1. 81	2. 17	1. 88	. 77	2. 61	1. 23	1. 81	2. 47	2. 02	1. 55

[1] Based on total weight of roots harvested.
[2] No data gathered in 1940.

provided the operators were properly trained and supervised to insure digging to a sufficient depth. A tractor-drawn middlebuster worked satisfactorily in 1942 at that location; the data of table 16 show that cutting injuries in that year were significantly lower than in 1940 and 1941, when mule power was used. The adequate power for ease of deep digging, even when soil conditions might not be at the best, probably had much to do with this more satisfactory performance of the mechanically powered digger. That team-drawn equipment can be quite satisfactory, however, is shown by the Blackville results. In all 3 years a team-drawn, "blackland" turning plow was used to plow deeply at a uniform depth. The data show that the percentage of cut roots was uniformly low in all three tests at that location. Under most conditions diggers of the turning-plow types are probably more satisfactory than the middlebuster type.

At all four locations, as the work crews learned their tasks better, there were general trends toward reductions in quantities of roots cut in succeeding tests. Regardless of location or year, any conditions that facilitate deep digging, whether they be due to soil type, preparation, and handling, use of the proper type and powering of equipment, or better training and supervision of workers doing the digging, will tend to minimize the amount of cutting injury during harvest.

HEIGHT OF RIDGE

Although the data presented in tables 16 and 17 indicate a lack of statistical significance of differences in some tests, height of ridges usually had considerable influence on the quantities of roots cut. The number of tests in which the yields of cut roots were reduced with increasing height of ridges leaves little doubt as to the importance of medium or high ridges in keeping digging injuries at a minimum. The greater amount of cutting of roots grown on low ridges is doubtless due in part to the greater difficulties of operating the harvesting equipment deeply enough to avoid striking the low-lying roots. Since both ideal digging equipment and the best possible use of it will be often unavailable, the use of the higher ridges, under such conditions as described for these tests, can help avoid many digging injuries that might otherwise occur.

Statistical analysis of the cut-root yield data showed significant interactions of ridge heights with times of harvest in all 3 years at Meridian and in the combined 1941–42 results at Tifton. In these tests, the extent of cutting injuries occurring with a given ridge height varied significantly among the various harvests, owing perhaps to differences in operation of harvesting equipment at the several harvests.

NITROGEN LEVEL

The data in table 16 show that in most tests the nitrogen level was without any significant effect on root cutting at harvest. However, significantly larger quantities of roots were cut in harvesting the high- than the low-nitrogen plots in 1941 at Meridian and in 1942 at Gilmer. The combined tests for Meridian, Gilmer, and Tifton in 1941 and for Blackville in 1941 and Blackville, Gilmer, and Meridian in 1942 also indicated that significantly more roots were cut in the high-nitrogen plots.

Despite the lack of significance of nitrogen effect on cutting of roots in many tests, 12 of the 15 tests or test combinations showed larger quantities of cut roots from the high-nitrogen than from the low-nitrogen treatment. Similarly, when the average quantities of cut roots were expressed as percentages of total weights (table 17), those for the high-nitrogen treatment again exceeded those for the low-nitrogen one in 7 of 11 individual tests, were exceeded by the low-nitrogen in 3 tests, and were essentially equal to those of the low-nitrogen in the remaining test.

At Gilmer in 1942 there were highly significant interactions of nitrogen levels with times of harvest and with ridge heights. However, the single effect of nitrogen in that test was significantly greater than the interactions of nitrogen × ridges or nitrogen × harvests.

It seems probable that most of the effect of nitrogen on weight of roots cut in harvesting is directly associated with the generally higher yields from the high-nitrogen plots.

TIME OF HARVEST

The data presented in table 16 indicate significant variations in quantities of cut roots among harvests in several single-year trials and among harvests combined by years and locations. However, these results do not show any over-all relation of time of harvest to root cutting. At Blackville, where the amount of cutting was consistently small, the maximum injury usually occurred in either the first or the second harvest periods. At the other three locations singly (wherever significance of differences among times of harvest was indicated), at Blackville and Meridian combined for 1940, and at Meridian, Gilmer, and Tifton combined for 1941, the maximum cutting occurred at either the third or the fourth harvests. Usually when the quantities of cut roots were expressed as percentages (by weight), as shown in table 17, these same time-of-harvest relations were maintained. At Meridian in 1942, however, the percentage of cut stock was highest at the first harvest, although the actual weights of cut roots were significantly highest at the third harvest.

INFLUENCE OF VARIOUS FACTORS ON FLESH COLOR OF ROOTS

A deep-salmon-pink flesh in roots of the Porto Rico sweetpotato is associated with a relatively high content of carotene (provitamin A). Consumers are becoming increasingly conscious of the value of high-vitamin products, and this attitude is reflected in an increasing demand for sweetpotatoes of the Porto Rico type with deep-salmon-pink flesh. Any cultural or handling operations that influence the intensity of color, and consequently the carotene content, are therefore important.

Anderson and associates (*1*), in Mississippi, and Kimbrough, Fieger, and Lewis (*6*), in Louisiana, showed that sweetpotatoes from plants set after mid-June contained less carotene at harvest than those from plants set earlier in the season. Other cultural factors, including those discussed herein, may have direct or indirect influences on intensity of color.

In the present studies no analyses were made of the carotene contents of the roots. Instead, root colors were evaluated in terms of the corresponding salmon-pink (i. e., red) values shown in standard color charts. There were only slight variations in the yellow values involved in these flesh-color readings. Concentrated solutions of pure β-carotene are brick-red, but dilute solutions such as occur in sweetpotato roots have a yellowish appearance. Ezell and Wilcox (*3, 4*) found that the ratio of carotene to total carotenoid pigments increases as the percentage of total carotenoid pigments increases and that "the depth of color of the flesh proved to be a reliable indication of the provitamin A value" (*4, p. 211*). It is assumed, therefore, that in the present studies higher contents of carotene were indicated as the intensities of pink or salmon-pink flesh colors increased. The discussion which follows relates only to the salmon-pink (red) values in flesh color near the stem end of the roots, studied at all locations except Blackville, where the readings were made for the average color of the flesh of the entire roots. The color in Porto Rico sweetpotatoes is usually less intense at the root end than at the stem end.

Flesh-color data for the various harvests in the several years and locations are presented in tables 18 to 20.

HEIGHT OF RIDGE

Only 1 of the 10 tests in which flesh-color readings were made showed significant differences in root color associated with variations in height

TABLE 18.—*Influence of time of harvest and sampling before and after storage on flesh-color indices* [1] *of Porto Rico sweetpotatoes grown at Blackville, 1941–42*

Year and time of sampling	Color index for indicated time of harvest [2]				L. S. D.[3] between harvest means
	First	Third	Fourth	Mean	
1941:					
Before storage	3. 47	3. 90	4. 11	3. 83	0. 16
After storage for 33, 29, and 25 weeks, respectively	4. 46	4. 65	4. 94	4. 68	. 17
Mean	3. 96	4. 28	4. 53	4. 26	. 18**
L. S. D.[3] between sampling period means	. 27	. 27	. 27	. 15**	
1942:					
Before storage	3. 90	4. 13	4. 28	4. 11	. 16
After storage for 34, 28, and 26 weeks, respectively	4. 48	4. 67	4. 95	4. 70	. 22
Mean	4. 19	4. 40	4. 62	4. 40	. 18**
L. S. D.[3] between sampling period means	. 24	. 24	. 24	. 15**	

**Variances significant at 1-percent level.

[1] Arbitrary index values for color: 3, pink; 4, three-fourths pink and one-fourth salmon-pink; 5, one-half pink and one-half salmon-pink. (Pink and salmon-pink as used approximate the colors peach, Maerz and Paul (*9, pl. 9*), and trianon (*9, pl. 9*) to salmon (*9, pl. 10*).)

[2] Color indices not determined for second harvests.

[3] Least significant difference at 5-percent level.

of ridge. At Tifton in 1942 mean color indices of 4.26, 4.48, and 4.74 were obtained for the low, medium, and high ridges, respectively, with a required difference between ridge heights of 0.20 for significance at the 5-percent level. Analysis of the data indicated highly significant variances due to height of ridge with respect to both error and the interaction heights of ridge × harvests.

Notwithstanding the highly significant treatment differences observed in this one test, it appears that under most growing conditions internal color of roots of the Porto Rico variety is not materially influenced by the height of ridge on which the crop is grown.

NITROGEN LEVEL

The data for the 10 tests at the 4 locations in 3 years show no significant differences in flesh color which could be ascribed to the differences in the amount of nitrogen applied to the crop. In general, these results agree with those obtained by Swanson and associates (*15*) and by Speirs and associates (*14*). Their results showed only minor and generally nonsignificant variations in vitamin A and carotene contents, respectively, in Porto Rico sweetpotatoes as a result of different fertilizer applications including various amounts of nitrogen.

TABLE 19.—*Influence of time of harvest and sampling at digging and after storage on flesh-color indices*[1] *of Porto Rico sweetpotatoes grown at Tifton, Meridian, and Gilmer, 1940–42*

Location, year, and time of sampling	Color index for indicated time of harvest					L. S. D.[2] between harvest means
	First	Second	Third	Fourth	Mean	
Tifton (1940):						
At digging	------	------	5.41	5.76	[3]5.58	0.26
After storage for 23, 20, 16, and 13 weeks, respectively	5.73	5.98	5.97	6.06	[3]6.01	.22
Mean	------	------	5.69	5.91	[3]5.80	.28*
L. S. D.[2] between sampling period means	------	------	.28	.28	.20**	------
Tifton (1941):						
At digging	5.85	5.16	5.15	5.84	5.50	.28
After storage for 23, 20, 16, and 13 weeks, respectively	5.86	5.92	5.83	5.86	5.87	(4)
Mean	5.85	5.54	5.49	5.85	5.68	.18**
L. S. D.[2] between sampling period means	.25	.25	.25	.25	.12**	------
Meridian (1941):						
At digging	6.87	7.07	7.28	7.45	7.17	.18
After storage for 31, 28, 25, and 21 weeks, respectively	7.30	7.69	7.70	7.69	7.60	.05
Mean	7.08	7.38	7.49	7.57	7.38	.10**
L. S. D.[2] between sampling period means	.15	.15	.15	.15	.07**	------
Meridian (1942):						
At digging	6.25	6.52	6.85	6.95	6.64	.21
After storage for 29, 26, 22, and 19 weeks, respectively	7.15	7.18	7.23	7.25	7.20	(4)
Mean	6.70	6.85	7.04	7.10	6.92	.14**
L. S. D.[2] between sampling period means	.19	.19	.19	.19	.10**	------
Gilmer (1941):						
At digging	6.27	6.13	6.21	7.42	6.51	.21
After storage for 24, 22, 20, and 16 weeks, respectively	5.92	6.47	6.23	6.18	6.20	.36
Mean	6.09	6.30	6.22	6.80	6.35	.20**
L. S. D.[2] between sampling period means	.28	.28	.28	.28	.14**	------

*Variances significant at 5-percent level.

**Variances significant at 1-percent level.

[1] See numerical designations of red color values given by Maerz and Paul (*9, pls. 9 and 10*). Larger index values indicate more intense salmon-pink flesh colors.

[2] Least significant difference at 5-percent level.

[3] Means for third and fourth harvests.

[4] Differences not significant at 5-percent level.

TABLE 20.—*Influence of time of harvest on mean flesh-color indices*[1] *of Porto Rico sweetpotatoes grown at Tifton and Gilmer, 1940 and 1942*

Location and year	Color index for indicated time of harvest				L. S. D.[2] between harvest means
	First	Second	Third	Fourth	
Tifton (1942)	4. 28	4. 67	4. 73	4. 30	0. 23**
Gilmer (1940)	6. 53	4. 62	7. 44	7. 01	. 33**
Gilmer (1942)	5. 99	5. 92	5. 98	6. 28	. 19**

**Variances significant at 1-percent level.

[1] See numerical designations of red color values given by Maerz and Paul (*9*, *pls. 9* and *10*). Larger index values indicate more intense salmon-pink flesh colors.

[2] Least significant difference at 5-percent level.

The accumulated evidence indicates, therefore, that flesh color of Porto Rico sweetpotatoes probably is not significantly altered by the applications of nitrogenous fertilizers that are likely to be used on this crop.

TIME OF HARVEST

The data in tables 18 to 20 show progressive increases in color intensity with successive times of harvest from the first through the fourth harvests in 1941 and 1942 at Blackville and Meridian, from the third to the fourth harvest at Tifton in 1940, and from the first through the third harvest at Tifton in 1942. Color values were less consistent at Tifton in 1941 and at Gilmer in all 3 years than in the tests just mentioned.

In general in these tests, flesh color was improved more by delaying the time of harvest 4 to 10 weeks than by shorter delays in digging after the earliest harvest dates. It is not clear why the mean color index at the first harvest date at Tifton in 1941 was as large as that of the fourth harvest made about 10 weeks later or why the index for the second digging at Gilmer in 1940 was so much lower than that for any other harvest. Nevertheless, for the most part, interior color of roots increased as time of harvest was deferred.

These results do not entirely agree with those obtained by Kimbrough, Fieger, and Lewis (*6*). These investigators conducted time-of-planting tests at the Louisiana Agricultural Experiment Station and transplanted plants of the Unit I Porto Rico at 3- to 4-week intervals, starting on April 27, and determined the carotene content of the fleshy roots at approximately monthly intervals, beginning about 3 months after planting. In general, the results showed that carotene content was lowest at the first harvest, when the roots were usually small and very immature, but that "early dug sweetpotatoes of usable size may be as high or higher in carotene content than those from the same planting date dug later" (*p. 401*).

Results of the present studies indicate that this statement may not always be true. The recent studies by Ezell and Wilcox (*4*) suggest an explanation for such differences. The condition of the precursors of carotene in roots at the time they are harvested may determine whether increases in carotene content are observed thereafter. If there has already been considerable transformation of the precursors into carotene at the time of a first harvest or sampling, then later samplings may indicate smaller or nondetectable increases in carotene content; whereas if the precursor-to-carotene transformation has not occurred to any appreciable extent at the first of a succession of samplings larger and readily detectable differences may be observed subsequently. Size alone is not a reliable indicator of "maturity" of roots. In fact, there is no very satisfactory definition of what is commonly called "maturity" of sweetpotatoes.

STORAGE

Data from flesh-color readings obtained in seven tests after the roots had been stored for 13 to 34 weeks are summarized in tables 18 and 19. In every test except that at Gilmer in 1941, the data show highly significant increases in mean intensity of color between lots examined before storage and comparable lots examined at the end of storage. At Gilmer in 1941 only the roots from the second harvest showed an appreciably higher mean color index after storage than those examined immediately after digging. Analysis of data from this test showed highly significant variances due to the interaction of times of harvest with the color-sampling periods before and after storage, indicating that there were significant variations in color responses to storage among the several harvests. The explanation for these variable responses is not known. In this test variances due to time of sampling for color were not significant when compared with those for the interaction between times of harvest and of sampling.

The trends toward higher mean color values with delays in time of harvest, just noted for roots examined before storage, usually continued in corresponding samples after the roots were stored. Moreover, after storage the mean color index for the roots from the first harvest usually exceeded or was only slightly less than that for the roots from the fourth harvest before they were stored.

It seems probable that the increases in color during storage would have been even larger for late-harvested lots had the color readings been made after equally long periods of storage for the several harvests. Substantial increases in carotene and vitamin A values in Porto Rico sweetpotatoes during storage of one to several months were reported by MacLeod and associates (*7*), MacLeod and Utley (*8*), Miller and Covington (*10*), and Ezell and Wilcox (*4*). On the other hand, Mitchell and Lease (*11*) reported only slight changes in the carotene content of Porto Rico roots held at room temperature for 4 months and a slight decrease when held at 37° C.; and Speirs and associates (*14*) concluded that storage had relatively little effect on carotene content of the Porto Rico grown in Georgia and North Carolina and harvested from late October to mid-November. Speirs and associates stated (*p. 18*) that "significant increases in carotene content for certain storage intervals in each experiment indicated a tendency for this constituent to accumulate during storage."

SUMMARY AND CONCLUSIONS

Cooperative studies of the influence of height of ridge, nitrogen supply, and time of harvest on the yield, grade, cutting damage at harvest, and flesh color before and after storage of Unit I Porto Rico sweetpotatoes were conducted at Tifton, Ga., Meridian, Miss., Blackville, S. C., and Gilmer, Tex., in 1940, 1941, and 1942.

Both locations and years were important factors in determining the differences in total and No. 1 grade root yields to be expected with different ridge-height and nitrogen-level treatments. Total yields were usually less variable among years and locations than were the separate grades constituting the totals.

Usually average yields of roots of No. 1, No. 2, and all grades combined increased as heights of ridge increased from low to medium and from medium to high. Yields of Jumbo and cull-grade roots were not materially altered by the height of ridge on which the crops were grown.

Average No. 1 grade, Jumbo, and total root yields were usually significantly higher for the high-nitrogen level (48–100 pounds per acre) than for the low-nitrogen level (10–20 pounds per acre).

Of the factors studied variations in time of harvest caused the greatest differences in No. 1 grade and total yields. Highly significant successive increases in mean total yields usually occurred as the times of harvests were delayed by two or in some cases three successive 2- to 4-week intervals after about September 1. Corresponding successive increases in average No. 1 grade yields also occurred with these delays in harvests at all locations except Gilmer. Although the relative proportions of No. 1 and No. 2 grades in the total yields varied with locations and years, in general the proportion of the No. 1 grade increased and the proportion of the No. 2 grade correspondingly decreased with delay in time of harvest, at least up to the third. In general, for maximum yield and percentage of No. 1 grade roots the harvest should be made as near to the first-killing-frost date or to the time of onset of fall rains or low temperatures as practicable without unduly risking dangers from cold injury during harvest and subsequent handling.

Considerable differences were found in the quantities of roots cut during harvest in different tests at the four locations. Usually more roots were cut on low-ridge plots than on medium- or high-ridge plots. Although there were differences in the extent of root cutting among harvests and between high- and low-nitrogen treatments, it seems probable that most of these were associated with differences in root yields and were not caused directly by the time of digging or the nitrogen level.

Any conditions which facilitate running the plow at the proper depth, whether they be due to soil type, soil preparation and handling, use of proper type and powering of equipment, or better training and supervision of workers, will minimize injury during harvest.

In general, flesh color improved progressively with delay in time of harvest, and the two nitrogen levels and the three heights of ridge had no significant differential effect on flesh color. Roots examined after they were stored 13 to 34 weeks had more intense color than corresponding lots examined at the harvests. During storage, roots from later harvests continued to exhibit more intense internal colors than roots from earlier harvests.

Applications of nitrogenous fertilizers somewhat higher than those commonly used in most districts producing the Porto Rico variety did not cause poorer internal color of roots than did light applications.

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